Effective Use of Geospatial Tools in Highway Construction

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Sponsor Acknowledgment

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Agenda
1. Purpose of Research
2. Overview of Geospatial Tools
3. UAS and Part 107
4. Applications and Tool Selection
5. ROI Case studies
6. Future Directions
7. Questions

Purpose
• Answers some of the following questions:
  • What is the resolution and accuracy (network and local) achievable through each technology or tool?
  • How does tools support highway construction, e.g. topographic surveys, earthwork quantity take-offs, visual inspection, etc.?
  • Where does each technology fit within the spectrum of geospatial technologies already available?
  • How does an owner/contractor/consultant choose which tool is best for a given construction scenario or situation?
  • What benefit can the owner realize by using the tool (in terms of ROI)?

Overview of Geospatial Tools
• UAS
  • Surveying and mapping
  • Construction monitoring and inspection
  • Bridge inspections
• Lidar
  • Airborne (linear mode, single photon, and Geiger-mode)
  • Terrestrial (mobile and static)
• Photogrammetry and SfM
  • Traditional workflows
  • SfM algorithms
• GNSS
  • Static, rapid-static, and kinematic
UAS and Part 107

- New FAA Small UAS Rule
  - "First operational rules for routine commercial use of small unmanned aircraft systems (UAS or "drones")" (FAA)
  - Goal to open operation of sUAS in the National Airspace System (NAS) to commercial use
  - Went into effect August 29, 2016
  - Previously, private sector firms had to obtain Section 333 exemption and obtain a COA
  - Time consuming and expensive => prohibitive for commercial firms to develop UAS service line

UAS and Part 107

- Limitations
  - Aircraft must be registered
  - Visual line of sight (VLOS) only (unless you have an exemption/waiver)
  - First-person view cannot satisfy "see-and-avoid"
  - Daylight only
  - May not operate over any persons not directly participating, not under a covered structure, and not inside covered stationary vehicle
  - Below 400 ft AGL or within 400 ft of a structure
  - Class G airspace
  - Min. Wx visibility of 3 miles

Applications and Tool Selection

### Examples of Use

<table>
<thead>
<tr>
<th>Task</th>
<th>Design</th>
<th>Construction</th>
<th>Asset Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Scans</td>
<td>Traditional Mapping</td>
<td>Change detection</td>
<td>Capturing/ 3D modeling of existing structures</td>
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<tr>
<td>Roadway Scans</td>
<td>Lidar</td>
<td>Car-mounted Lidar</td>
<td>Change detection</td>
</tr>
<tr>
<td>Roadway Scans</td>
<td>Topographic Scans</td>
<td>Change detection</td>
<td>Capturing/ 3D modeling of existing structures</td>
</tr>
<tr>
<td>Roadway Scans</td>
<td>Mobile Scan</td>
<td>Car-mounted Lidar</td>
<td>Change detection</td>
</tr>
</tbody>
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Source: Adapted from Olsen and Gillins, 2015

UAS and Part 107

- Improvements over Section 333 exemption
  - Do not need pilot’s license - need remote pilot certificate
  - Pass an initial aeronautical knowledge test
  - Be vetted by TSA
  - ≥ 16 yrs old
  - Airworthiness certification not required for aircraft
  - Not required to file a NOTAM
  - Do not need a visual observer
  - Not required to coordinate with or give notice to airports in Class G (uncontrolled) airspace
  - Allows for the use of UAS for educational purposes
## Oregon ROI Applications

### Applications and Tool Selection

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<th>Task</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Small area feature mapping</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Primary survey control (tie and staked)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>GNSS (static)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Small area feature mapping</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Paving</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Primary and secondary survey control</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>GNSS (static)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3D tech</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

### Project-specific conditions to consider:
- **Data collection magnitude**
  - How large is the area of interest?
  - Project complexity
  - How many critical features need to be mapped/measured?
  - Vertical accuracy (horizontal accuracy secondary with 3D tech)
  - How accurate does the data need to be vertically?
  - Resolution/level of development
  - How detailed does the point cloud/model need to be?
  - Speed of delivery
    - How soon is the data needed?
  - Operator safety risk
    - What level of safety risk is allowable for the instrument operator?
  - Weather requirements
    - Are there any weather constraints to collecting the required data?

## ROI Case Studies

### Oregon DOT’s Use of Geospatial Data Acquisition from Design to Paver
- Innovative demonstration event for intelligent construction systems and technologies (3D design, AMG, and others)
- Scope included:
  - Site survey
  - 3D design
  - Construction
  - QA/QC
  - As-built survey

### Oregon DOT’s Use of Geospatial Data Acquisition from Design to Paver
- Lessons learned provided valuable ROI:
  - Demonstrations of technology in action highlight benefits
  - Engaging upper management with hands-on activities using the technologies quickly generates interest
  - Effective handoff between design and construction is critical
  - Have a technology implementation plan for the project as well as a backup plan
  - Close coordination of multiple stakeholders to mitigate risks is important
  - Oregon DOT immediately saw high ROI from this workshop and resulted in creating a new Engineering Automation Division due to leadership support and engagement at this event
  - [http://designtopaver.org](http://designtopaver.org)
ROI Case Studies

- Oregon DOT’s Use of sUAS for Bridge Inspections
  - UAS flights at 4 bridges
  - UAS are most effective for visual and routine bridge inspections (non-fracture critical inspections)
  - UAS are less beneficial in inspections of fracture-critical or functionally obsolete bridges
  - “arm’s length” requirement
  - UAS unable to probe or scrape
  - Nearly all aspects of visual inspection can be accomplished with UAS; can improve viewing angles and resolution

- Utah DOT’s Use of Geospatial Technology for Design and Construction Applications
  - SR20 project
  - sUAS were used to assess data quality for 3D models
  - Other technologies were used to achieve required tolerances in areas UAS could not meet
  - GNSS was used for measuring quantities and verifying elevations
  - Found difficult to isolate a single tool (sUAS) as indicator of benefits
    - Combination of tools and processes is necessary

ROI Case Studies

- Oregon DOT’s Use of sUAS for Bridge Inspections
  - ROI
    - Benefits
      - Cost savings: equipment rental/usage (e.g. snooper cranes), traffic control, and travel (lodging, meals, incidentals).
      - Reduced field time
        - Average savings of 7 days (with two people)
        - Improved safety measures
    - Costs
      - UAS system (sensfly Albris) = $19,079
      - Travel/field time - 20%
      - Office time = 30%

ROI Case Studies

- Utah DOT’s Use of Geospatial Technology for Design and Construction Applications
  - Qualitative benefits:
    - Improved safety by reducing exposure
    - Improved data quality of daily reports
    - Improved data measurements for quantities
    - Visualization of project progress for public information
  - Quantitative benefits:
    - Inspector productivity
      - 50% time savings
    - Quantity measurements
      - 30% time savings
  - Costs
    - UAS (hardware and software) = $10,959
    - Tablets = $1,000
    - GNSS Rovers = $62,000

Future Directions

- Improved sensor capabilities
  - Improved accuracy and resolution
  - Speed and efficiency
  - Size and weight
  - Key ROI challenge: determining the optimal data quality (accuracy and resolution)

- Software enhancements
  - Integrating larger range of spatial data types
  - Efficiently handle larger datasets
  - Task automation
  - Computer vision algorithms (SfM)
  - Cloud computing
  - Interoperability between systems
  - Key ROI challenge: cybersecurity

Future Directions

- Proliferation of geospatial technology
  - New applications of geospatial technology
  - Location-based services and information
  - Key ROI challenge: more education and training to understand limitations of technology; ease of use and availability may lead to inappropriate use of technology

- UAS Technology
  - Direct georeferencing reducing need for ground control
  - Decreased costs of hardware
  - Improved payload capability
  - Miniaturization of sensors
  - Sense and avoid technology
  - Key ROI challenge: limited battery life
Future Directions

• Integration of multiple sensors on a single platform
  • Key ROI challenge: coordinating the various data streams and calibrating the individual sensors
• ROI determination
  • Improving sharing and reporting of experiences with others, including the documentation of failures
  • ROI will need to be realized in shorter time frame due to speed of technology evolution
  • Key challenge: resource planning to determine frequency and upgrades/updates of technology

Questions?